Apprenticeship and Industry Training

Power System Electrician

Apprenticeship Course Outline

4614.2 (2014)

Alberta

Apprenticeship and Industry Training

ALBERTA INNOVATION AND ADVANCED EDUCATION

Power System Electrician: Apprenticeship Course Outline

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Power System Electrician
Table of Contents

Power System Electrician Table of Contents 1
Apprenticeship 2
Apprenticeship and Industry Training System 2
Apprenticeship Safety 4
Procedures for Recommending Revisions to the Course Outline 5
Apprenticeship Route toward Certification 6
Power System Electrician Training Profile 7

Course Outline

First Period Technical Training 13
Second Period Technical Training 22
Third Period Technical Training 27
Fourth Period Technical Training 36

Apprenticeship

Apprenticeship is post-secondary education with a difference. Apprenticeship begins with finding an employer. Employers hire apprentices, pay their wages and provide on-the-job training and work experience. Approximately 80 per cent of an apprentice's time is spent on the job under the supervision of a certified journeyperson or qualified tradesperson. The other 20 per cent involves technical training provided at, or through, a post-secondary institution – usually a college or technical institute.

To become certified journeypersons, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board on the recommendation of Power System Electrician Provincial Apprenticeship Committee.

The graduate of the Power System Electrician apprenticeship program is a certified journeyperson who will be able to:

- responsibly do all work tasks expected of a journeyperson
- supervise, train and coach apprentices
- use and maintain hand and power tools to the standards of competency and safety required by the trade
- read and interpret drawings, plans and specifications and layout and develop projects according to specifications
- coordinate power system work with other trades employed in the industry in both construction and maintenance
- perform assigned tasks in accordance with quality and production standards required by industry

Apprenticeship and Industry Training System

Industry-Driven

Alberta's apprenticeship and industry training system is an industry-driven system that ensures a highly skilled, internationally competitive workforce in more than 50 designated trades and occupations. This workforce supports the economic progress of Alberta and its competitive role in the global market. Industry (employers and employees) establishes training and certification standards and provides direction to the system through an industry committee network and the Alberta Apprenticeship and Industry Training Board. The Alberta government provides the legislative framework and administrative support for the apprenticeship and industry training system.

Alberta Apprenticeship and Industry Training Board

The Alberta Apprenticeship and Industry Training Board provides a leadership role in developing Alberta's highly skilled and trained workforce. The board's primary responsibility is to establish the standards and requirements for training and certification in programs under the Apprenticeship and Industry Training Act. The board also provides advice to the Minister of Advanced Education on the needs of Alberta's labour market for skilled and trained workers, and the designation of trades and occupations.

The thirteen-member board consists of a chair, eight members representing trades and four members representing other industries. There are equal numbers of employer and employee representatives.

Industry Committee Network

Alberta's apprenticeship and industry training system relies on a network of industry committees, including local and provincial apprenticeship committees in the designated trades, and occupational committees in the designated occupations. The network also includes other committees such as provisional committees that are established before the designation of a new trade or occupation comes into effect. All trade committees are composed of equal numbers of employer and employee representatives. The industry committee network is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the board can set up a local apprenticeship committee. The board appoints equal numbers of employee and employer representatives for terms of up to three years. The committee appoints a member as presiding officer. Local apprenticeship committees:

- monitor apprenticeship programs and the progress of apprentices in their trade, at the local level
- make recommendations to their trade's provincial apprenticeship committee (PAC) about apprenticeship and certification in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- make recommendations to the board about the appointment of members to their trade's PAC
- help settle certain kinds of disagreements between apprentices and their employers
- carry out functions assigned by their trade's PAC or the board

Provincial Apprenticeship Committees (PAC)

The board establishes a provincial apprenticeship committee for each trade. It appoints an equal number of employer and employee representatives, and, on the PAC's recommendation, a presiding officer - each for a maximum of two terms of up to three years. Most PACs have nine members but can have as many as twenty-one. Provincial apprenticeship committees:

- Make recommendations to the board about:
    - standards and requirements for training and certification in their trade
    - courses and examinations in their trade
    - apprenticeship and certification
    - designation of trades and occupations
    - regulations and orders under the Apprenticeship and Industry Training Act
- monitor the activities of local apprenticeship committees in their trade
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- consult with other committees under the Apprenticeship and Industry Training Act about apprenticeship programs, training and certification and facilitate cooperation between different trades and occupations
- consult with organizations, associations and people who have an interest in their trade and with employers and employees in their trade
- may participate in resolving certain disagreements between employers and employees
- carry out functions assigned by the board

Power System Electrician PAC Members at the Time of Publication

Mr. Rodger Pierce	Calgary	Presiding Officer
Mr. David Bissett	Calgary	Employer
Mr. Gord Christensen	Sherwood Park	Employer
Mr. Brent Shaben	Edmonton	Employer
Mr. Ryan Olmstead	Calgary	Employee
Mr. Daniel Taylor	Fort McMurray	Employee
Mr. Shawn Lawrence	Calgary	Employee

Alberta Government

Alberta Advanced Education works with industry, employer and employee organizations and technical training providers to:

- facilitate industry's development and maintenance of training and certification standards
- provide registration and counselling services to apprentices and employers
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

Technical Institutes and Colleges

The technical institutes and colleges are key participants in Alberta's apprenticeship and industry training system. They work with the board, industry committees and Alberta Advanced Education to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs. They develop lesson plans from the course outlines established by industry and provide technical training to apprentices.

Apprenticeship Safety

Safe working procedures and conditions, incident/injury prevention, and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees, apprentices and the public. Therefore, it is imperative that all parties are aware of circumstances that may lead to injury or harm.

Safe learning experiences and healthy environments can be created by controlling the variables and behaviours that may contribute to or cause an incident or injury. By practicing a safe and healthy attitude, everyone can enjoy the benefit of an incident and injury free environment.

Alberta Apprenticeship and Industry Training Board Safety Policy

The Alberta Apprenticeship and Industry Training Board (board) fully supports safe learning and working environments and emphasizes the importance of safety awareness and education throughout apprenticeship training- in both on-the- job training and technical training. The board also recognizes that safety awareness and education begins on the first day of on-the-job training and thereby is the initial and ongoing responsibility of the employer and the apprentice as required under workplace health and safety training. However the board encourages that safe workplace behavior is modeled not only during on-the-job training but also during all aspects of technical training, in particular, shop or lab instruction. Therefore the board recognizes that safety awareness and training in apprenticeship technical training reinforces, but does not replace, employer safety training that is required under workplace health and safety legislation.

The board has established a policy with respect to safety awareness and training:

> **The board promotes and supports safe workplaces, which embody a culture of safety for all apprentices, employers and employees. Employer required safety training is the responsibility of the employer and the apprentice, as required under legislation other than the *Apprenticeship and Industry Training Act.***

The board's complete document on its 'Apprenticeship Safety Training Policy' is available at www.tradesecrets.alberta.ca; access the website and conduct a search for 'safety training policy'.

Implementation of the policy includes three common safety learning outcomes and objectives for all trade course outlines. These common learning outcomes ensure that each course outline utilizes common language consistent with workplace health and safety terminology. Under the title of 'Standard Workplace Safety', this first section of each trade course outline enables the delivery of generic safety training; technical training providers will provide trade specific examples related to the content delivery of course outline safety training.

Occupational Health and Safety

A tradesperson is often exposed to more hazards than any other person in the work force and therefore should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code when dealing with personal safety and the special safety rules that apply to all daily tasks.

Occupational Health and Safety (A division of Alberta Human Services) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.humanservices.alberta.ca

Technical Training

Apprenticeship technical training is delivered by the technical institutes and many colleges in the public post-secondary system throughout Alberta. The colleges and institutes are committed to delivering the technical training component of Alberta apprenticeship programs in a safe, efficient and effective manner. All training providers place great emphasis on safe technical practices that complement safe workplace practices and help to develop a skilled, safe workforce.

The Power System Electrician trade has common first and second period with the Powerline Technician trade.

The following institutions deliver Power System Electrician apprenticeship technical training:

Northern Alberta Institute of Technology

Procedures for Recommending Revisions to the Course Outline

Advanced Education and has prepared this course outline in partnership with the Power System Electrician Provincial Apprenticeship Committee.

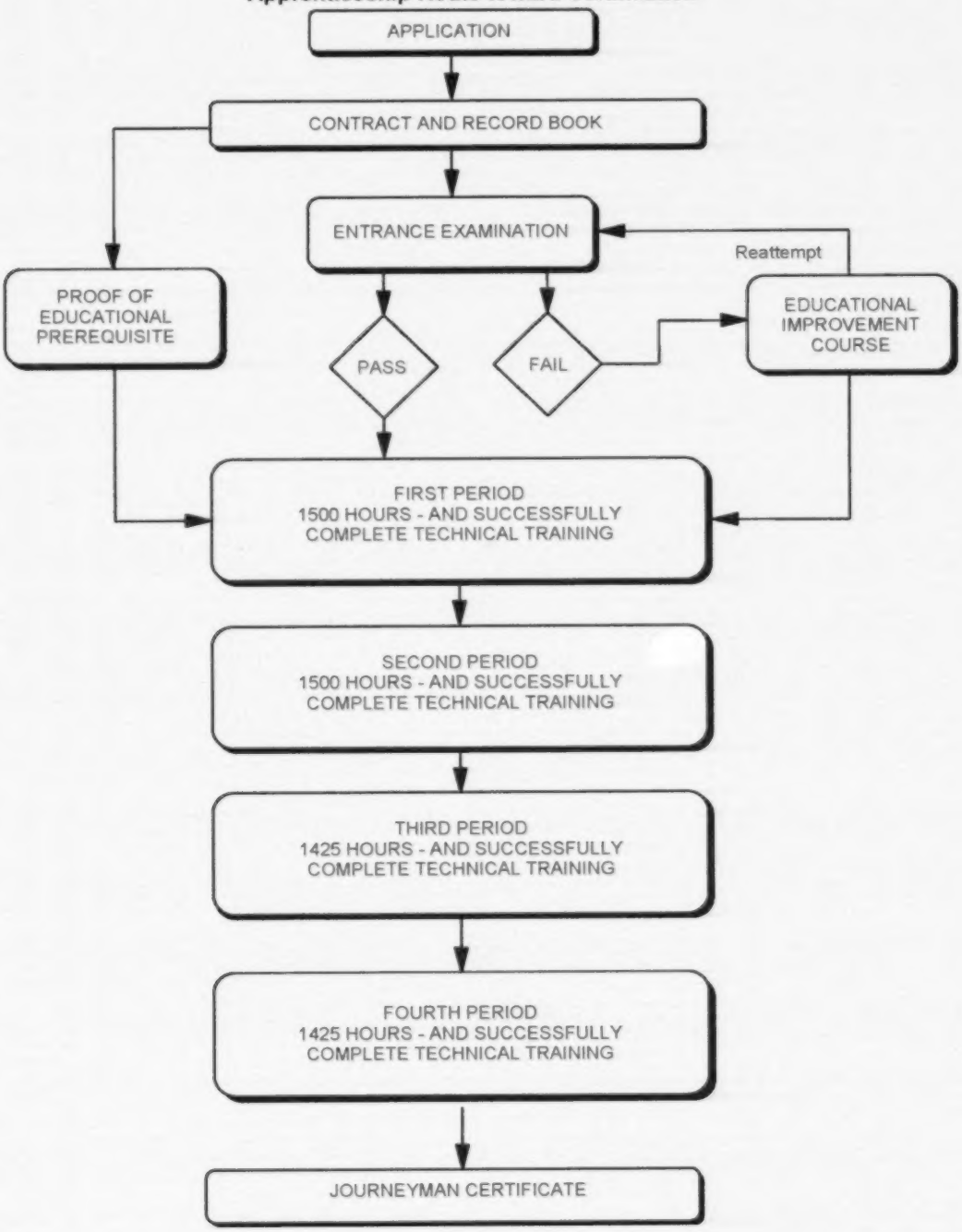
This course outline was approved on November 1, 2013 by the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. The valuable input provided by representatives of industry and the institutions that provide the technical training is acknowledged.

Any concerned individual or group in the province of Alberta may make recommendations for change by writing to:

Power System Electrician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
Advanced Education
10th floor, Commerce Place
10155 102 Street NW
Edmonton AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations for change will be placed on the agenda for regular meetings of the Power System Electrician Provincial Apprenticeship Committee.

Apprenticeship Route toward Certification



Power System Electrician Training Profile
FIRST PERIOD
(7 Weeks 30 Hours per Week – Total of 210 Hours)

SECTION ONE

STANDARD WORKPLACE SAFETY AND CODES
28 HOURS

A	B	C
Safety Legislation, Regulations & Industry policy in the Trade 4 Hours	Climbing, Lifting, Rigging and Hoisting 3 Hours	Hazardous Materials & Fire Protection 3 Hours
D	**E**	**F**
Personal Protective Equipment and Arc Flash 6 Hours	Introduction to Personal Protective Grounding 4 Hours	Introduction to Apprenticeship 2 Hours
G		
AEUC Section 0,2 and 4 6 Hours		

SECTION TWO

INTRODUCTION TO ELECTRICAL THEORY
49 HOURS

A	B	C
Trade Mathematics 4 Hours	Electrical Fundamentals 4 Hours	Series Resistive Circuits 6 Hours
D	**E**	**F**
Parallel Resistive Circuits 6 Hours	Series-Parallel Resistive Circuits 6 Hours	Power, Line Loss, and Voltage Drop 5 Hours
G	**H**	**I**
Edison Three Wire Distribution Systems 7 Hours	Electromotive Force 5 Hours	Phasors 6 Hours

SECTION THREE

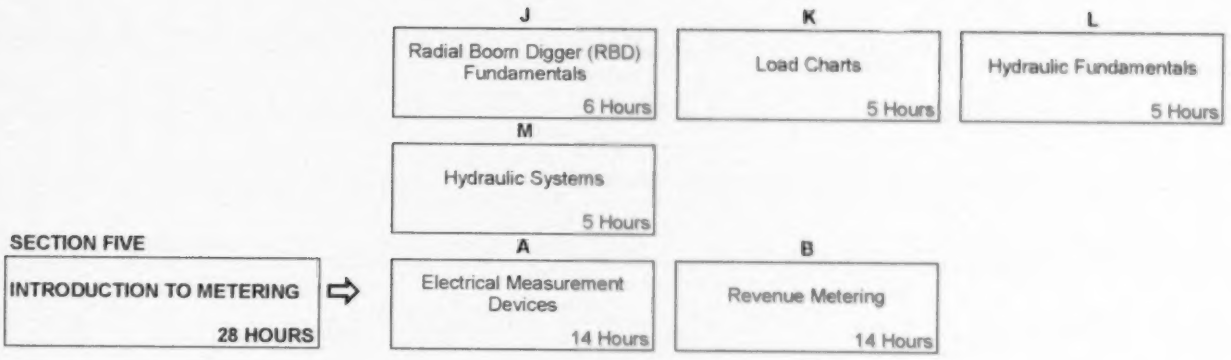
INTRODUCTION TO TRANSFORMER THEORY
35 HOURS

A	B	C
Magnetism 5 Hours	Transformer Basics 5 Hours	Transformer Operation 5 Hours
D	**E**	**F**
Transformer Ratings 5 Hours	Transformer Windings and Tap Changers 5 Hours	Transformer Installation 5 Hours
G		
Transformer Cooling and Dielectric 5 Hours		

SECTION FOUR

OVERHEAD LINE CONSTRUCTION
70 HOURS

A	B	C
Powerline Poles 5 Hours	Pole Setting and Climbing Safety 6 Hours	Insulators 5 Hours
D	**E**	**F**
Anchors and Guys 4 Hours	Conductors 6 Hours	Conductors Stringing 5 Hours
G	**H**	**I**
Splicing and Terminating 6 Hours	Trade Tools and Equipment 6 Hours	Rigging and Hoisting 6 Hours


J
Radial Boom Digger (RBD) Fundamentals
6 Hours
K
Load Charts
5 Hours
L
Hydraulic Fundamentals
5 Hours
M
Hydraulic Systems
5 Hours
SECTION FIVE
INTRODUCTION TO METERING
28 HOURS
A
Electrical Measurement Devices
14 Hours
B
Revenue Metering
14 Hours

SECOND PERIOD
(7 Weeks 30 Hours per Week – Total of 210 Hours)

SECTION ONE

INTERMEDIATE ELECTRICAL THEORY
70 HOURS

A	B	C
Resistance in ac Circuits 2 Hours	Inductance and Inductive Reactance 12 Hours	Capacitance and Capacitive Reactance 12 Hours
D	**E**	**F**
Impedance in Series Resistive-Reactive Circuits 14 Hours	Impedance in Parallel Resistive-Reactive Circuits 14 Hours	Single Phase Power and Power Factor 10 Hours
G		
Basic Three Phase Systems 6 Hours		

SECTION TWO

INTERMEDIATE TRANSFORMER THEORY
42 HOURS

A	B	C
Transformer Applications 4 Hours	System Grounding 6 Hours	Transformer Impedance 10 Hours
D	**E**	
Three Phase Transformer Connections 18 Hours	Three Phase Distribution Transformer Installations 4 Hours	

SECTION THREE

UNDERGROUND LINE CONSTRUCTION AND STREET LIGHTING
49 HOURS

A	B	C
Legal Land Descriptions 4 Hours	Underground Distribution 10 Hours	Underground Cable Termination and Splicing 11 Hours
D	**E**	
Underground Distribution Testing and Troubleshooting 8 Hours	Street Lighting and Relays 16 Hours	

SECTION FOUR

INTERMEDIATE METERING
28 HOURS

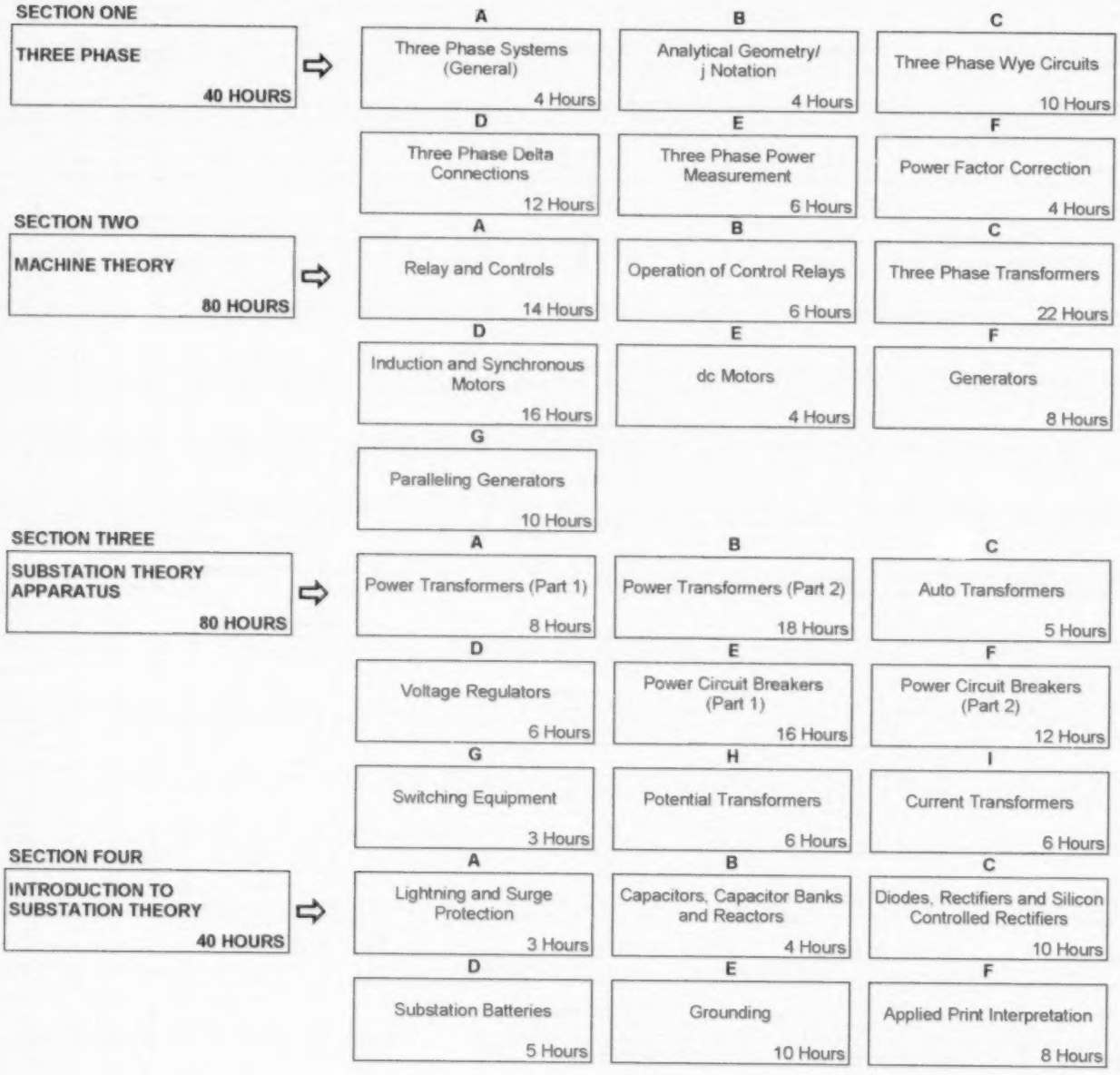
A	B	C
Electrical Measuring and Recording and Indicating Devices 6 Hours	Instrument Transformers 10 Hours	Instrument Rated Revenue Metering 12 Hours

SECTION FIVE

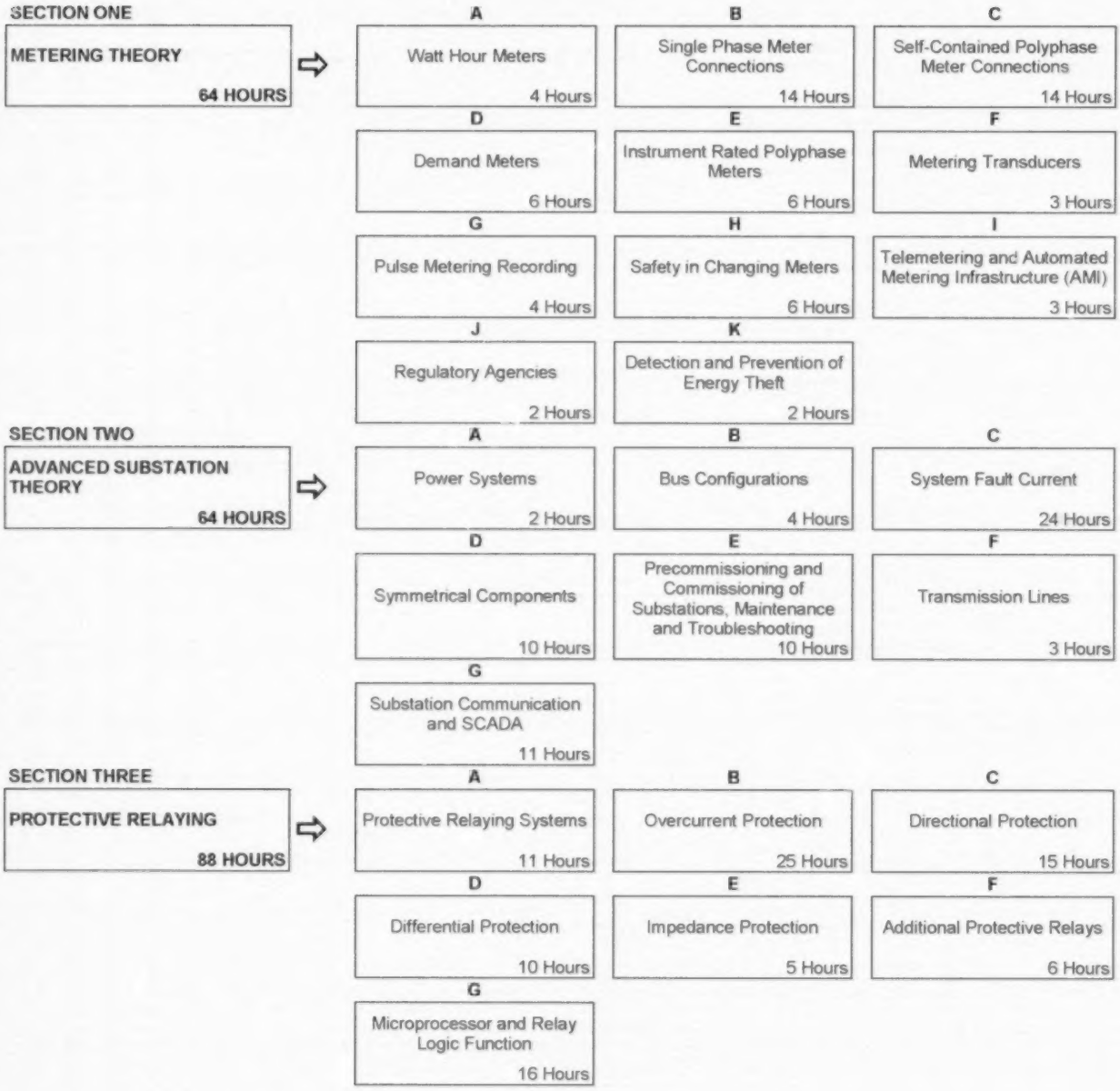
UTILITY CODES AND SAFETY
21 HOURS

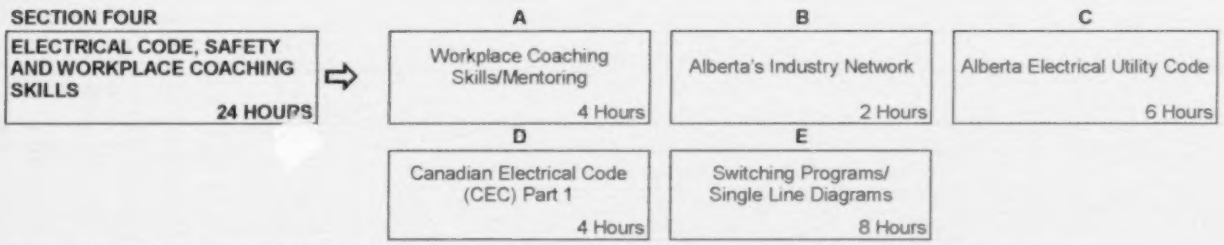
A	B
Personal Protective Grounding 14 Hours	AEUC Section 6, 10 and 12 7 Hours

THIRD PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)



FOURTH PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)





NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training.

FIRST PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... STANDARD WORKPLACE SAFETY AND CODES ..... 28 HOURS

A. Safety Legislation, Regulations & Industry Policy in the Trade ..... 4 Hours

Outcome: Describe legislation, regulations and practices intended to ensure a safe work place in this trade.

1. Demonstrate the ability to apply the Occupational Health and Safety Act, Regulation and Code.
2. Describe the role of the employer and employee in regard to Occupational Health and Safety (OH&S) regulations, Worksite Hazardous Materials Information Systems (WHMIS), fire regulations, Workers Compensation Board regulations, and related advisory bodies and agencies.
3. Explain industry practices for hazard assessment and control procedures.
4. Describe the responsibilities of workers and employers to apply emergency procedures.
5. Describe positive tradesperson attitudes with respect to housekeeping, personal protective equipment and emergency procedures.
6. Describe the roles and responsibilities of employers and employees with respect to the selection and use of personal protective equipment (PPE).
7. Select, use and maintain appropriate PPE for worksite applications.

B. Climbing, Lifting, Rigging and Hoisting ..... 3 Hours

Outcome: Describe the use of personal protective equipment (PPE) and safe practices for climbing, lifting, rigging and hoisting in this trade.

1. Select, use and maintain specialized personal protective equipment (PPE) for climbing, lifting and load moving equipment.
2. Describe manual lifting procedures using correct body mechanics.
3. Describe rigging hardware and the safety factor associated with each item.
4. Select the correct equipment for rigging typical loads.
5. Describe hoisting and load moving procedures.

C. Hazardous Materials & Fire Protection ..... 3 Hours

Outcome: Describe the safety practices for hazardous materials and fire protection in this trade.

1. Describe the roles, responsibilities features and practices related to the Workplace Hazardous Materials Information System (WHMIS) program.
2. Describe the three key elements of WHMIS.
3. Describe handling, storing and transporting procedures when dealing with hazardous materials.
4. Describe safe venting procedures when working with hazardous materials.
5. Describe fire hazards, classes, procedures and equipment related to fire protection.

D. Personal Protective Equipment and Arc Flash ..... 6 Hours

Outcome: Describe the inspection, care and maintenance of PPE.

1. List the inspection and maintenance procedures for lineman's climbing belts and pole straps as per OH&S Code (part 9).
2. Describe the care, maintenance and storage of protective rubber gloves, sleeves, live line tools and live line cover-up.
3. Illustrate the daily inspection of protective rubber gloves, sleeves, live line tools and live line cover-up.
4. Describe the visual and dielectric testing of protective rubber gloves, sleeves, live line tools and live line cover-up.
5. List the types and applications of hot sticks and accessories.
6. Describe the causes and consequences of arc flash.

E. Introduction to Personal Protective Ground ..... 4 Hours

Outcome: Describe personal protective grounding.

1. Describe the hazards of current through a human body.
2. Identify the hazards that personal protective grounds guard against.
3. Identify the electrical and mechanical requirements of a personal protective ground.
4. Outline the procedure for installing and removing personal protective grounds.

F. Introduction to Apprenticeship ..... 2 Hours

Outcome: Describe the apprenticeship system.

1. Describe the apprenticeship system as it relates to apprentices training and responsibilities.
2. Describe the apprenticeship system as it relates employer's responsibilities in the apprenticeship systems.

G. EUC Sections 0,2, and 4 ..... 6 Hours

Outcome: Apply Electrical Utility Code (EUC) as it relates to sections 0, 2 and 4.

1. Interpret section "0" of the EUC.
2. Interpret section "2" of the EUC.
3. Interpret section "4" of the EUC.

SECTION TWO: ..... INTRODUCTION TO ELECTRICAL THEORY ..... 49 HOURS

A. Trade Mathematics ..... 4 Hours

Outcome: Solve trade related problems using mathematical skills.

1. Perform basic math calculations.
2. Define the terms ratio and direct proportion and perform calculations using both.
3. Convert between SI and Imperial units of measurement.
4. Solve linear, area, volume, weight and temperature problems.
5. Transpose simple algebraic equations to solve for one unknown.
6. Solve right angle triangles using trigonometry.

B. Electrical Fundamentals.....4 Hours

Outcome: Solve basic electrical problems.

1. Describe the fundamental relationship between the structure of the atom and the flow of electrons.
2. Describe the units of measurement for basic electrical terms and symbols.
3. Apply Ohm's Law to electrical circuit calculations.
4. Connect circuits to verify the relationships between voltage, current, and resistance.

C. Series Resistive Circuits.....6 Hours

Outcome: Analyze a series resistive circuit.

1. Define a series circuit and calculate current in a series circuit.
2. Describe the formula for total resistance and calculate resistance in a series circuit.
3. Describe Kirchhoff's voltage law as it relates to a series circuit.
4. Describe the relationship between the resistive values of components and their voltage drops and solve problems using the voltage divider rule.
5. Determine the voltage drop across a closed-or-open-circuit component in a series circuit.
6. Connect to verify Kirchhoff's current and voltage laws in a series resistive circuit.

D. Parallel Resistive Circuits.....6 Hours

Outcome: Analyze a parallel resistive circuit.

1. Define a parallel circuit.
2. Describe the formula for total resistance and calculate resistance in a parallel circuit.
3. Describe Kirchhoff's current law as it relates to a parallel circuit.
4. Describe the effects of open or short circuited components in a parallel circuit.
5. Use the current divider principle to calculate branch currents.
6. Connect to verify Kirchhoff's current laws in a parallel resistive circuit.

E. Series-Parallel Resistive Circuit.....6 Hours

Outcome: Analyze a basic series-parallel resistive circuit.

1. Identify series and parallel portions of a simple series-parallel resistive circuit.
2. Calculate the total resistance of a series-parallel circuit.
3. Apply Kirchhoff's current law in a series-parallel circuit.
4. Apply Kirchhoff's voltage law in a series-parallel circuit.
5. Solve problems involving series-parallel circuits.
6. Connect to verify the relationship of current, voltage and resistance in each part of a series/parallel circuit.

F. Power, Line Loss, and Voltage Drop.....5 Hours

Outcome: Describe power, energy, line loss, and voltage drop in electrical circuits.

1. Describe and calculate power and energy.
2. Describe and calculate voltage drop and its effect on circuits as current changes.

3. Describe and calculate line loss.
4. Connect circuits to verify power formulae.

G. Edison Three Wire Distribution Systems.....7 Hours

Outcome: Analyze Edison three wire distribution systems and the effects of an open neutral.

1. Describe a basic three wire distribution system and list its advantages.
2. Solve problems involving balanced and unbalanced three wire distribution.
3. Solve problems involving an open neutral on balanced and unbalanced three wire distribution systems.
4. Verify the effects of an open neutral on three wire distribution systems.

H. Electromotive Force.....5 Hours

Outcome: Describe Electromotive Force.

1. Define Electromotive Force (EMF).
2. Describe the production of EMF using chemicals, heat, light, and pressure.
3. Describe the connection of batteries in series and in parallel.
4. Describe the production of EMF using magnetism.
5. Describe standard ac sine wave values including instantaneous, RMS, and maximum.
6. Describe the relationship between cycles, poles, and frequency.
7. State nominal voltages used on utility systems.

I. Phasors.....6 Hours

Outcome: Solve single phase phasor problems.

1. Describe phasors and vectors.
2. Describe leading and lagging phasors.
3. Perform phasor addition using rectangular and polar calculations.

SECTION THREE:.....INTRODUCTION TO TRANFORMER THEORY.....35 HOURS

A. Magnetism.....5 Hours

Outcome: Describe the principles of magnetism, electromagnetism, and electromagnetic induction.

1. Describe the properties of magnetic materials.
2. Define the terminology related to magnetism.
3. Describe electromagnetism and basic design considerations for electromagnetic devices.
4. Describe the process of electromagnetic induction.

B. Transformer Basics.....5 Hours

Outcome: Describe the construction and identification of transformers.

1. Describe the purposes and applications of transformers.
2. List the basic components and the nameplate information of a transformer.

3. Describe the standard terminal and winding identification.
4. Identify the primary and secondary terminals of a transformer and differentiate between step up and step down.

C. Transformer Operation.....5 Hours

Outcome: Describe the operation and loading of transformers.

1. Describe the operation of a transformer at no load (excitation).
2. Describe the operation of a transformer as load is added.
3. List the losses that occur in a transformer.
4. State why utilities may accept 100% efficiency for transformer calculations.

D. Transformer Ratings.....5 Hours

Outcome: Describe transformer voltage ratings.

1. State how transformers are rated and typically manufactured.
2. Solve problems involving transformer voltage, turns, and current ratios.
3. Describe the possible effects of operating a transformer at greater than rated voltage.
4. Calculate the rated primary and secondary currents of a transformer from nameplate data.
5. Select a properly rated transformer for a specified load.
6. Connect to verify transformer voltage, turns, and current ratios.

E. Transformer Windings and Tap Changers.....5 Hours

Outcome: Describe transformer windings and tap changers.

1. Differentiate between additive and subtractive polarity.
2. Describe why tap changers are used.
3. Describe how to set a tap changer to increase or decrease secondary voltage levels.
4. Determine the approximate voltage change when taps are changed to various steps.
5. Describe the steps required to safely change the tap setting on a tap changer.
6. Connect multi-winding transformers for series or parallel operation and calculate primary and secondary voltage levels.

F. Transformer Installation.....5 Hours

Outcome: Describe the installation of distribution transformers.

1. List the items to be checked prior to installing a transformer.
2. Select the size of fuse from a fuse chart for a given transformer.
3. Describe the connection of a lightning arrestor.
4. Define the causes of backfeed, hazards involved, and how to avoid them.
5. Describe the grounding of a single phase secondary service.
6. Identify the hazards of improper grounding.

G. Transformer Cooling and Dielectric.....5 Hours

Outcome: Describe transformer cooling methods and dielectric oil.

1. Describe the various methods of cooling of transformers.
2. Identify the hazards of PCBs as related to transformer oils.
3. Describe how impurities in oil affect its dielectric strength.
4. Describe how to take an oil sample and how it is tested.

SECTION FOUR:.....OVERHEAD LINE CONSTRUCTION .....70 HOURS

A. Power Line Poles .....5 Hours

Outcome: Describe powerline structures and their handling.

1. Describe the types of powerline structures.
2. Describe the treatments used for powerline poles.
3. Define the differences between classes of wood poles.
4. Identify the information found on pole stamps.
5. Describe basic framing and attachments to wood poles.
6. Describe the procedures for loading, hauling and unloading of poles.

B. Pole Setting and Climbing Safety.....6 Hours

Outcome: Describe pole installation and climbing.

1. Describe the forces exerted on power line structures.
2. Identify the standardized markings that are used in Alberta to mark location of underground facilities.
3. List the hazards involved in power digging and how to minimize these hazards.
4. Describe methods of setting poles.
5. Determine when pole cover up and rubber gloves are required to be used when setting poles.
6. Describe the factors that affect how poles are faced in various situations.
7. Describe problems caused when poles are improperly backfilled and tamped.
8. Describe the hazards involved in climbing poles.

C. Insulators.....5 Hours

Outcome: Describe the characteristics of insulators used in powerline construction.

1. List the common types of insulator materials used on power systems.
2. Describe the different type of insulators and their applications.
3. Define B.I.L. (basic impulse level) rating of power system insulators.
4. Define flashover and leakage current.
5. Define dielectric strength of insulating materials.
6. Identify typical causes of insulator failure.
7. List common causes and methods of prevention of radio/TV interference.

D. Anchors and Guys.....4 Hours

Outcome: Describe the application of anchors and guys used in powerline construction.

1. Describe the types and holding capacities of powerline anchors.
2. Describe the proper installation of typical anchor types.
3. Describe the proper placement of anchors and state reasons for anchor failure.
4. Calculate guy tensions.

E. Conductors.....6 Hours

Outcome: Describe the type of conductors used in powerline construction.

1. Describe the advantages and disadvantages of various types of material used for line conductors.
2. Recognize conductor sizes with the use of American Wire Gauge (AWG).
3. Describe the relationship between the size and ampacity of conductors.
4. Describe common aerial conductor types.

F. Conductor Stringing.....5 Hours

Outcome: Describe methods of stringing and recovering powerlines.

1. Describe common methods of handling and storage of reels of conductor.
2. Describe common methods of stringing and recovering power line conductors.
3. Describe the fundamental relationship between tension and sag.
4. Describe the methods used for conductor tie-in.

G. Splicing and Terminating.....6 Hours

Outcome: Describe how to splice, connect and terminate overhead conductors.

1. Describe the use of manual and power driven presses.
2. Describe how to check for proper compression.
3. Describe the preparation of conductors for splicing and deadending.
4. Identify the proper conductor splicing sleeves and press dies using reference charts (include automatic type splices).
5. Identify the proper insulated sleeve for low voltage conductor splicing from reference charts.
6. Demonstrate manufacturer's operating and maintenance practices for explosive actuated tools.

H. Trade Tools and Equipment.....6 Hours

Outcome: Describe the inspection, care, and maintenance of tools.

1. Describe the selection, use and operation of basic line construction tools.
2. Describe the sharpening of climber gaffs.
3. Describe care, maintenance and safety precautions for power and hand tools.

I. Rigging and Hoisting.....6 Hours

Outcome: Describe rigging and hoisting practices.

1. Identify types and ratings of synthetic rope.
2. Describe the causes and effects of shock loading on rigging.
3. Describe how to reeve a set of multiple rope blocks.
4. Demonstrate how to reeve a set of multiple rope blocks.
5. Calculate the mechanical advantage of rope blocks.
6. Demonstrate common knots and hitches on rope.
7. Estimating load weights for rigging and hoisting purposes.

J. Radial Boom Digger (RBD) Fundamentals ..... 6 Hours

Outcome: Describe hoisting and operating principles of a RBD.

1. Demonstrate knowledge of crane and hoisting signals.
2. Describe the importance of crew communications when operating load handling equipment.
3. Identify the inspection and maintenance of a RBD.
4. Describe the hazards and procedures for the inspection, setup and use for a RBD.
5. Describe the operating characteristics.

K. Load Charts..... 5 Hours

Outcome: Interpret load charts.

1. Describe the purpose of load charts.
2. Describe the effect of quadrants of operation on capacity.
3. Describe how capacities are affected by attachments.
4. Describe how capacities are affected by the location of the load in relationship to the unit.
5. Describe how capacities are affected by setup.

L. Hydraulic Fundamentals..... 5 Hours

Outcome: Describe fundamental hydraulic principles.

1. Apply Pascal's Law.
2. Describe the operation of a hydraulic cylinder.
3. Describe the operation of a control valve.
4. Describe the operation of a hydraulic pump.
5. Describe the operation of a hydraulic motor.

M. Hydraulic Systems ..... 5 Hours

Outcome: Describe the hydraulic systems on RBD's.

1. Identify the components.
2. Describe the functions of components.
3. Describe the hydraulic flow through a system.
4. Identify how the environment affects hydraulic systems.

SECTION FIVE: ..... INTRODUCTION TO METERING ..... 28 HOURS

A. Electrical Measurement Devices ..... 14 Hours

Outcome: Demonstrate the use of electrical measuring devices.

1. Describe the care, connections and safety precautions for common electrical measuring devices.
2. Demonstrate accurate measurements using common electrical measuring devices.
3. Demonstrate range selection and wiring connections for common electrical measuring devices.

B. Single Phase Revenue Metering ..... 14 Hours

Outcome: Verify operation of single phase self-contained revenue metering.

1. Describe the basic operation of a kWhr meter.
2. Read a single–phase meters (energy and demand).
3. Verify socket connections prior to changing or installing a new meter.
4. Describe what a clock-over and a complete clock-over are.
5. Connect to verify correct operation of a single phase three wire energy meter.

SECOND PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:.....INTERMEDIATE ELECTRICAL THEORY ..... 70 HOURS

A. Resistance in ac Circuits ..... 2 Hours

Outcome: Describe how resistors affect an ac circuit.

1. Analyze an ac circuit containing resistors connected in series.
2. Analyze an ac circuit containing resistors connected in parallel.

B. Inductance and Inductive Reactance..... 12 Hours

Outcome: Describe the effects of inductance on ac and dc circuits.

1. Describe a basic inductor (coil).
2. Describe inductance and the factors which affect it.
3. Describe induction and its effects.
4. Describe the effects of an inductor in a dc circuit.
5. Describe the effects of an inductor in an ac circuit.
6. Analyze an ac inductive circuit.
7. Describe the power relationships in an ac inductive circuit.
8. Connect to verify ac circuits containing inductance.

C. Capacitance and Capacitive Reactance ..... 12 Hours

Outcome: Describe the effects of capacitance on ac and dc circuits.

1. Describe the construction of a basic capacitor.
2. Describe capacitance and the factors which affect it.
3. Describe the effects of a capacitor in a dc circuit.
4. Describe the effects of a capacitor in an ac circuit.
5. Analyze an ac capacitive circuit.
6. Describe the power relationships in an ac capacitive circuit.
7. Explain the hazards of refusing capacitors.
8. Connect to verify ac circuits containing capacitance reactance.

D. Impedance in Series Resistive-Reactive Circuits..... 14 Hours

Outcome: Describe impedance in series resistive reactive circuits.

1. Describe impedance in a series RL circuit.
2. Describe impedance diagrams and their relationship to phasor diagrams and power diagrams in series circuits.
3. Describe power factor and phase angle.

4. Describe impedance for series RC circuits.
5. Describe series RLC circuits and the hazards associated with them.
6. Connect to verify series resistive–reactive circuits.

E. Impedance in Parallel Resistive-Reactive Circuits ..... 14 Hours

Outcome: Analyze parallel resistive reactive circuits.

1. Describe impedance in a parallel RL circuit.
2. Describe impedance diagrams and their relationship to phasor diagrams and power diagrams in parallel circuits.
3. Describe parallel RL circuits.
4. Describe parallel RC circuits.
5. Describe parallel RLC circuits.
6. Connect to verify parallel resistive-reactive circuits.

F. Single Phase Power and Power Factor ..... 10 Hours

Outcome: Describe power and power factor.

1. Define true, apparent and reactive power.
2. Connect to verify true, apparent and reactive power
3. Define power factor.
4. Describe the reasons for correcting power factor.
5. Solve power factor correction calculations.
6. Connect to verify power factor correction.

G. Basic Three Phase Systems ..... 6 Hours

Outcome: Describe basic three phase systems.

1. Describe basic three phase generation of voltages.
2. Describe wye connected loads and sources.
3. Describe delta connected loads and sources.

SECTION TWO: ..... INTERMEDIATE TRANSORMER THEORY ..... 42 HOURS

A. Transformer Applications ..... 4 Hours

Outcome: Describe transformers applications on power systems.

1. Describe the application of transformers in network distribution situations.
2. Describe the application of transformers in substation power situations.
3. Describe the application of transformers in general distribution situations.

B. System Grounding ..... 6 Hours

Outcome: Describe system grounding.

1. Describe the purpose of a system ground.
2. Describe the differences between neutral return systems and earth return systems.

3. Describe the hazards of an open neutral or an open ground connection.
4. Describe the function of a ground rod as an electrical connection.
5. Determine ground resistance by means of an earth resistance tester.

C. Transformer Impedance ..... 10 Hours

Outcome: Describe transformer impedance and paralleling of transformers.

1. Define percent impedance (%IZ).
2. Determine maximum secondary fault current using transformer nameplate information.
3. Describe the requirements for paralleling two single phase transformers.
4. Connect to verify the % IZ of a transformer.
5. Connect to verify how two single phase transformers in parallel share load.

D. Three Phase Transformer Connection ..... 18 Hours

Outcome: Determine the voltage relationships for standard three phase transformer connections.

1. Describe the voltage characteristics of standard three phase transformer connections.
2. Draw standard three phase transformer connections.
3. Connect to verify voltages of standard three phase transformer connections.

E. Three Phase Distribution Transformer Installation ..... 4 Hours

Outcome: Describe pre-installation requirements of transformers in a bank.

1. Determine the transformer connection by interpreting nameplate data.
2. Describe the possible internal winding connections that may be required before hanging transformers in a bank.
3. Determine fusing requirements for standard three phase transformer connections.
4. Describe the hazards of backfeeds and energized potentials from transformer banks.
5. Determine customer loading allowed for open wye and open delta connections.

SECTION THREE: .... UNDERGROUND LINE CONSTRUCTION AND STREET LIGHTING ..... 49 HOURS

A. Legal Land Descriptions ..... 4 Hours

Outcome: Describe the use of legal land descriptions in Alberta.

1. Describe the legal land description systems.
2. Locate a legal land description on a map.
3. Identify the legal land description of a location on a map.

B. Underground Distribution ..... 10 Hours

Outcome: Describe underground distribution systems.

1. Describe the advantages and disadvantages of underground distribution systems.
2. Identify associated components of underground systems.
3. Describe loop, radial and network systems.

4. Describe direct burial and ductwork installation of underground cable.
5. Describe the appropriate codes to be followed with installation.

C. Underground Cable Termination and Splicing ..... 11 Hours

Outcome: Describe methods used to terminate and splice underground cables.

1. Describe commonly used primary and secondary cables.
2. Describe the components and purpose of primary and secondary underground cables.
3. Describe the components and purpose of a high voltage termination.
4. Describe methods used to terminate and splice primary and secondary cables.
5. Identify a load break and a non-load break elbow.

D. Underground Distribution Testing and Troubleshooting ..... 8 Hours

Outcome: Describe testing and fault locating.

1. Describe the purpose of single line diagrams used for troubleshooting.
2. Verify proper system operation.
3. Interpret the operation of fault indicators.
4. Describe cable testing and fault locating methods.

E. Street Lighting and Relays..... 16 Hours

Outcome: Describe street lighting systems.

1. Describe the installation of street lighting components.
2. Describe operating characteristics of lamps used in street lighting.
3. Describe operating characteristics and connections of lamp ballasts.
4. Describe the disposal methods of lamps and ballasts.
5. Describe the operation of relays and photoelectric eyes.
6. Demonstrate relay operation.
7. Demonstrate street light circuits.

SECTION FOUR: ..... INTERMEDIATE METERING ..... 28 HOURS

A. Electrical Measuring, Recording, and Indicating Devices ..... 6 Hours

Outcome: Describe the purpose of electrical measuring, recording, and indicating devices.

1. Describe the purpose for the use recording devices.
2. Describe the purpose for the use measuring devices.
3. Describe the purpose for the use indicating devices.

B. Instrument Transformers ..... 10 Hours

Outcome: Describe the applications of instrument transformers.

1. Describe the function and ratings of potential transformers and their hazards.
2. Describe the function and ratings of current transformers and their hazards.
3. Describe primary and secondary fusing of potential transformers.

4. Describe current transformer grounding and shorting.
5. Connect to verify instrument transformer ratios.

C. Instrument Rated Revenue Metering ..... 12 Hours

Outcome: Describe the operation and connections of single phase instrument type revenue metering.

1. Describe the operation of an instrument rated revenue meter.
2. Calculate a load through a meter using kh.
3. Connect to verify the load on an energy meter.

SECTION FIVE: ..... UTILITY CODES AND SAFETY ..... 21 HOURS

A. Personal Protective Grounding ..... 14 Hours

Outcome: Describe methods of grounding for personal protection.

1. Describe how personal protective grounding minimizes electrical hazards.
2. Describe step and touch potential and state how fault current varies with proximity to sources of fault current.
3. Describe the factors affecting resistance of ground electrode connections and reasons for keeping temporary ground rods away from the base of poles.
4. Describe the principals of equal-potential bonding and grounding.
5. Describe the sequence to be followed when installing or removing protective grounds.

B. EUC Section 6, 10 and 12 ..... 7 Hours

Outcome: Apply Electrical Utility Code (EUC) as it relates to sections 6, 10 and 12.

1. Interpret section "6" of the EUC.
2. Interpret section "10" of the EUC.
3. Interpret section "12" of the EUC.

THIRD PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:.....THREE PHASE..... 40 HOURS

A. Three Phase Systems (General).....4 Hours

Outcome: Describe a three phase electrical system and its difference from a single phase system.

1. Describe the advantages of three phase power.
2. Describe the generation of three phase power.
3. Describe double subscript notation used on phasor drawings.
4. Describe phase sequence and rotation.
5. Operate phase sequence indicator.
6. Verify phase reversal on a three phase motor.

B. Analytical Geometry / j-Notation .....4 Hours

Outcome: Solve electrical problems utilizing analytical geometry and j-notation.

1. Locate a point in the correct quadrant when given its polar or rectangular co-ordinates.
2. Convert from polar to rectangular form and vice-versa.
3. Describe the meaning of the j-operator.
4. Properly locate a phasor on the horizontal or vertical axes following repeated multiplication by the j-operator in both clockwise and counter clockwise directions.
5. Solve electrical phasor problems with the j-operator.

C. Three Phase Wye Circuits .....10 Hours

Outcome: Describe the characteristics of Three Phase wye circuits.

1. Describe the voltage and current relationships for balanced and unbalanced circuits.
2. Draw a phasor diagram for balanced and unbalanced circuits.
3. Calculate the neutral current for unbalanced circuits.
4. Calculate the power factors for balanced and unbalanced circuits.
5. Measure voltage, current and phase angle in balanced and unbalanced three phase four-wire circuit.
6. Measure neutral current for a three phase four-wire circuit.
7. Calculate the true power consumed for balanced and unbalanced circuits.
8. Calculate the reactive power consumed for balanced and unbalanced circuits.
9. Calculate the apparent power consumed for balanced and unbalanced circuits.
10. Draw a power triangle for balanced and unbalanced circuits.

D. Three Phase Delta Connections ..... 12 Hours

Outcome: ***Connect and analyze the relationships between voltages and currents in delta-connected circuits.***

1. Describe the voltage and current relationships for balanced and unbalanced circuits.
2. Draw a phasor diagram for balanced and unbalanced circuits.
3. Calculate the power factor for balanced and unbalanced circuits.
4. Calculate the true power consumed for balanced and unbalanced circuits.
5. Calculate the reactive power consumed for balanced and unbalanced circuits.
6. Calculate the apparent power consumed for balanced and unbalanced circuits.
7. Draw a power triangle for balanced and unbalanced circuits.
8. Perform Delta-Wye/Wye Delta transformation calculations.
9. Measure voltage, current and phase angle in balanced and unbalanced three phase three wire circuits.

E. Three Phase Power Measurement ..... 6 Hours

Outcome: ***Describe and draw the connections for three phase metering and calculate meter readings.***

1. Describe power measurement using three wattmeters for balanced and unbalanced circuits.
2. Draw phasor diagram indicating the electrical quantities applied to each wattmeter for balanced and unbalanced circuits.
3. Describe Blondel's theorem.
4. Describe power measurement using two wattmeters.
5. Draw phasor diagrams indicating the electrical quantities applied to each wattmeter for balanced and unbalanced circuits.
6. Connect wattmeters to measure power in a three phase four wire balanced and unbalanced circuits.
7. Connect wattmeters to measure power in a three phase, three wire balanced and unbalanced circuits.

F. Power Factor Correction ..... 4 Hours

Outcome: ***Describe power factor correction and the methods of improving power factor for a circuit.***

1. Define power factor as it applies to a three phase system.
2. Describe how capacitors will correct the power factor of a circuit.
3. Determine how capacitors should be connected to a three phase system for power factor correction.
4. Perform and verify power factor correction calculations.
5. Describe how capacitors can be safely connected to and disconnected from a circuit.
6. Correct power factor in three phase circuits using wye and delta connected capacitor banks.

SECTION TWO: ..... MACHINE THEORY ..... 80 HOURS

A. Relays and Controls ..... 14 Hours

Outcome: Describe control circuits that use relays.

1. Define specific terms that are used when referring to control circuits.
2. Identify the parts of a relay.
3. Describe the operating principle of a relay.
4. Draw the symbols that are commonly used in control circuits.
5. Draw schematic and wiring diagrams using a relay.
6. Connect and analyze control circuits using relays.

B. Operation of Control Relays and Contactors ..... 6 Hours

Outcome: Describe the operation and basic components of control relays and contactors.

1. Identify the three main parts of a relay.
2. Describe the purpose of laminations and shading coils in relays and contactors.
3. State the advantages of double break or bridge contacts.
4. Describe the operation of a relay.
5. Describe timing and smart relays functions.
6. Interpret nameplate information and relay terminal connections.
7. Recognize and describe several common types of relays.
8. Connect and observe correct relay and contactor operation.

C. Three Phase Transformers ..... 22 Hours

Outcome: Describe connections and characteristics of three phase transformers.

1. Describe voltage, current and power relationships in all commonly used three phase transformer connections.
2. Determine the expected voltages and currents with the use of a phasor diagram.
3. Describe the common transformer ratings and the purpose of nameplate data.
4. Describe and calculate the ratio of transformation.
5. Determine rated and load values for line and phase currents and voltages for any transformer connection.
6. Define and determine angular displacement for any transformer bank.
7. Describe the operation and connection of two three phase transformers in parallel.
8. Compare phase and line voltage values to turns ratio of each transformer connection.
9. Draw schematic diagrams of three phase wye delta and delta-wye transformer banks connected according to American National Standard Institute (ANSI) standards.
10. Connect common transformer configurations.
11. Connect two three phase banks in parallel to feed a common load.
12. Measure transformer losses and calculate efficiency of three phase transformers.
13. Measure angular displacement of three phase transformer banks.

D. Induction and Synchronous Motors ..... 16 Hours

Outcome: Describe the theory of operation of induction and synchronous motors.

1. List the main types of induction motors.
2. State the functions of the principle parts of the squirrel cage induction motor.
3. Describe the principle of operation of an induction three phase motor.
4. Describe speed regulation and machine efficiency.
5. Describe the effect of full voltage starting on circuits, load and motor and describe operation of common motor starters.
6. Describe methods for reversing three phase motors.
7. Describe the effects of motor over and under voltage.
8. Identify the windings of a common three phase motor.
9. List the components of a synchronous motor.
10. Describe the principal of operation when used as a motor and for power factor correction.
11. Connect the motor to a source of voltage for which it is designed to operate.
12. Reverse the direction of rotation on three phase motors with and without reversing magnetics.

E. dc Motors ..... 4 Hours

Outcome: Describe the theory of operation of dc motors.

1. Describe the different types of construction for dc motors.
2. Draw a correctly labelled diagram of each type of dc motor.
3. Describe the operation of dc motors.

F. Generators ..... 8 Hours

Outcome: Describe the basic construction and theory of operation of a generator.

1. Describe the function, operation and connection of a generator stator and rotor.
2. Describe the principles of EMF induction.
3. Describe the characteristics and parameters associated with speed, poles and frequency.
4. Describe generator output voltage, waveform and voltage regulation.
5. Describe loading curves and overload capacity.
6. Describe shifting kW and kVAR load.
7. Describe generator excitation methods.
8. Connect a three phase generator and study its characteristics under lagging and leading load conditions.

G. Paralleling Generators ..... 10 Hours

Outcome: Describe the basic theory and methods of paralleling generators.

1. Describe conditions for and methods of parallel operation.
2. Describe a standby unit, switching procedures required and hazards of backfeed.
3. Describe basic generator testing.
4. Describe the principles of and hazards involved with co-generation.

5. Describe the principles of load shedding and islanding.
6. Describe the purpose and connection of a synchronism check relay.
7. Parallel three phase generators.

SECTION THREE: .....SUBSTATION THEORY APPARATUS ..... 80 HOURS

A. Power Transformer (Part 1).....8 Hours

Outcome: Describe the basic components and operating features of power transformers.

1. Identify and describe transformer nameplate data and its function.
2. Identify and describe core construction, losses, grounding and testing.
3. Identify and describe external transformer components.
4. Identify and describe cooling methods and insulating mediums.
5. Identify and describe transformer protective devices.
6. Describe on-load and off-load tap changers.

B. Power Transformer (Part 2).....18 Hours

Outcome: Demonstrate the testing procedures and troubleshooting skills used on power transformers.

1. Describe gas and oil sampling and testing and online monitoring.
2. Describe gas and oil sampling analysis as they relate to types of faults.
3. Identify and describe methods of transformer electrical testing.
4. Describe harmonics and their effect on electrical systems.
5. Describe how to troubleshoot transformer failures.
6. Describe methods of drying out transformers.
7. Describe sweep frequency response analysis.
8. Describe infrared testing and thermal imaging.
9. Determine hot spots on energized current carrying equipment using infrared and thermal imaging test equipment.
10. Measure and calculate humidity and dew point using electronic testers.
11. Measure the ratios and phase angle of a single and three phase transformer.
12. Perform a capacitance and dissipation factor bridge test on a transformer according to manufacturer's operating instructions.
13. Make a comparison to previous test using conversion factors for temperature.
14. Measure insulation resistance of a transformer using common industry test equipment.
15. Draw an oil sample and test for dielectric breakdown, neutralization value, interfacial tension and colour.
16. Describe and record wave forms of output voltage and excitation currents with and without a tertiary winding (at various voltage levels) for a transformer.

C. Autotransformers ..... 5 Hours

Outcome: Analyze the operation of an autotransformer.

1. Describe the operation of autotransformers.
2. Perform calculations related to the operation of an autotransformer.
3. Calculate transformed kVA and output kVA.
4. Determine the current rating of series and common windings.
5. Calculate the rated load that could be supplied by autotransformers connected in wye.
6. Connect an autotransformer to verify calculations.

D. Voltage Regulators ..... 6 Hours

Outcome: Describe the operating principles of various voltage regulators.

1. Describe the applications of voltage regulation in a power system.
2. Describe the different types, components and methods of voltage regulation.
3. Identify the maintenance procedures for a step voltage regulator.
4. Describe how to operate, switch and test a step voltage regulator.
5. Describe the operation of a sequenced and non-sequenced bypass switch.
6. Determine the voltage regulation of single phase transformers.

E. Power Circuit Breakers (Part 1) ..... 16 Hours

Outcome: Describe power circuit breaker characteristics and associated equipment.

1. Describe the physical characteristics of power circuit breakers.
2. Identify and describe common types of power circuit breakers, components and the advantages and disadvantages of each type and their applications.
3. Describe metal clad and metal enclosed switch gear enclosures.
4. Describe Gas Insulated Systems (GIS), hazards and environmental regulations.
5. Describe point on wave circuit breakers.

F. Power Circuit Breakers (Part 2) ..... 12 Hours

Outcome: Describe power circuit breaker operation, control and maintenance.

1. Describe a typical control schematic associated with circuit breakers.
2. Describe trip free operation.
3. Describe the various breaker characteristics that can be determined from an analyzer chart, breaker times and insulating medium testing.
4. Describe contact resistance and erosion.
5. Measure the contact resistance of a circuit breaker and switch.

G. Switching Equipment ..... 3 Hours

Outcome: Describe switching equipment.

1. Identify the types and applications of high voltage air, fused and bypass disconnect switches.
2. Describe the operation of a motor controlled switch.

3. Describe the methods used for arc interruption.
4. Describe the ratings of various types of interrupters.

H. Potential Transformers ..... 6 Hours

Outcome: Describe potential transformers including operation, ratings, polarity and accuracy.

1. Describe the operation of potential transformers.
2. Describe types of potential transformers.
3. Describe ratings and accuracy of potential transformers.
4. Describe potential transformer polarity.
5. Describe potential transformer test procedures.
6. Describe potential transformer connections.
7. Perform ratio and insulation tests on a potential transformer.
8. Verify polarity marks by open circuit ac method and inductive kick method.
9. Connect and provide proper protection for potential transformers.

I. Current Transformers ..... 6 Hours

Outcome: Describe current transformers including operation, ratings, polarity and accuracy.

1. Describe the operation of current transformers.
2. Describe types of current transformers.
3. Describe ratings and accuracy of current transformers.
4. Describe current transformer polarity.
5. Describe current transformer test procedures.
6. Describe current transformer connections.
7. Describe metering tanks.
8. Perform saturation, ratio and insulation tests on a current transformer.
9. Describe and demonstrate the proper method of de-magnetizing a current transformer.
10. Verify polarity marks by open circuit ac method and inductive kick method.
11. Connect different types of current transformers.

SECTION FOUR: ..... INTRODUCTION TO SUBSTATION THEORY ..... 40 HOURS

A. Lightning and Surge Protection ..... 3 Hours

Outcome: Describe the different types of lightning and protective equipment.

1. Describe the formation of and different types of lightning.
2. Describe the generation, the properties and the effects of switching surges in a power system.
3. Describe the types of lightning protective equipment including power line shields.
4. Describe the placement and grounding of lightning arrestors in a power system.
5. List the voltage ratings, classifications and monitoring of lightning arrestors.
6. Describe the type of tests and maintenance required for lightning arrestors.

B. Capacitors, Capacitor Banks and Reactors ..... 4 Hours

Outcome: Describe the use of capacitors and reactors in power systems.

1. Describe the construction, insulating medium and rating of capacitors.
2. Describe the grounding of capacitors and capacitor banks.
3. Describe the fusing and protection for capacitors and banks.
4. Describe the generation of transient voltages and currents due to the switching of capacitors and the ratings required by switches and circuit breakers.
5. Describe the operation of a static shunt compensator (static var system).
6. Identify the applications of reactors in power systems.
7. Describe the application of shunt and series reactors.

C. Diodes, Rectifiers and Silicon Controlled Rectifiers (SCR's) ..... 10 Hours

Outcome: Describe the characteristics of diodes, rectifiers and SCR's.

1. Identify and calculate basic voltage conversions, waveforms, notations for electronic circuits.
2. Describe the PN junction characteristics, symbol and ratings.
3. Identify and verify the diode terminals and ratings from a specification sheet.
4. Describe common types of half, full wave, single phase, three phase and six phase rectifier circuits.
5. State the diode ratings and draw the waveform associated with each rectifier.
6. State the purpose of and components for filters on rectifier circuits.
7. Describe the operation and applications of SCR's.
8. Demonstrate the use of common test instruments used for electronic circuits.

D. Substation Batteries and Chargers ..... 5 Hours

Outcome: Describe substation batteries, testing and applications.

1. Identify the types of batteries and ratings associated with substation battery banks.
2. Describe the hazards, applications and precautions associated with different types of substation battery banks.
3. Describe maintenance, testing and charging procedures for substation battery banks.
4. Describe the operation of and troubleshoot the rectifier stage of a battery charger.
5. Connect and troubleshoot a circuit that includes a rectifier or SCR used in a battery charger.
6. Perform battery impendence tests.

E. Grounding ..... 10 Hours

Outcome: Describe system grounding, equipment grounding and gradient control.

1. Describe the reasons and rationale for grounding.
2. Describe the types of hazards including earth gradients that may occur during a fault condition.
3. Describe factors affecting system grounds in different electrical systems.
4. Describe ungrounded systems and the factors affecting them.
5. Describe how a ground source is provided in zigzag and wye-delta configurations.
6. Describe the methods used for the detection of ground faults in ungrounded systems.

7. Describe equipment and substation fence grounding and the factors affecting it.
8. Describe static grounding and the factors affecting it.
9. Describe the reasons for surface gradient control.
10. Describe how grid conductor, grounding conductor and connectors are selected.
11. Describe how the maximum ground fault current is determined.
12. Describe how to measure the resistance of a ground rod and the resistivity of the substation grid.
13. Describe the hazards associated with overhead shielded wires, underground cables and repairing of static ground grids.

F. Applied Print Interpretation..... 8 Hours

Outcome: Read and interpret information from a drawing or print.

1. Demonstrate a familiarity with parts lists, legends, symbols, abbreviations and IEEE device numbers from prints.
2. State the purpose of specifications and the use of standards.
3. Describe trade related information from a set of structural drawings of a substation.
4. Describe trade related information from a set of electrical prints of a substation.
5. Identify all equipment connected to each phase on a single line drawing.
6. Identify all equipment connected to each phase on a three phase drawing.

FOURTH PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... METERING THEORY ..... 64 HOURS

A. Watt Hour Meters ..... 4 Hours

Outcome: Describe various watt-hour meters.

1. Describe the theory and operation of induction type watt-hour meters.
2. Describe the theory and operation of electronic watt-hour meters.
3. Describe bi-directional watt hour meters.

B. Single Phase Meter Connections ..... 14 Hours

Outcome: Describe various common meter and instrument transformer connections in single phase systems using formula and phasor diagrams.

1. Review two and three wire meter connections.
2. Describe the operation of a three-wire CT meter connection on a three wire circuit.
3. Describe the two CT method of metering a three wire circuit using a two wire watt-hour meter.
4. Describe the operation of a network watt-hour meter.
5. Describe metering connections by using formulae and phasor diagrams.
6. Describe the function, operation and hazards of test switches.
7. Connect and verify a three wire current transformer to properly measure the energy of a three wire, single phase load using a two wire kWh meter.
8. Connect and verify the connection of 2 current transformers to properly measure the energy of a three wire single phase load using a two wire kWh meter.
9. Connect and verify the results of a network kWh meter used to properly measure the energy of a three wire circuit feed from a wye supply.
10. Determine and verify the billing multiplier for a metering point that uses CT's in the circuit.
11. Describe and check the results of incorrect primary or secondary polarity connections on the preceding CT connections.

C. Self-Contained Polyphase Meter Connections ..... 14 Hours

Outcome: Describe self-contained polyphase meter connections in three phase systems using formula and phasor diagrams.

1. Describe three phase self-contained watt-hour meter connections for two, two and half and three element meters for wye and delta systems.
2. Describe metering connections by using formulae and phasor diagrams.
3. Connect and verify a two element kWh meter feed from a three phase delta supply.
4. Install and verify a $2^1/_2$ and a 3 element kWh meter for wye-four wire supply.
5. Install and verify a $2^1/_2$ and a 3 element kWh meter for delta-four wire supply.

D. Demand Meters ..... 6 Hours

Outcome: Describe various demand meter connections using formulae and phasor diagrams.

1. Define "demand meter" and describe their importance to a Utility.
2. Identify and describe the application and purpose of demand meters for kVA or kW measurement.
3. Describe how the demand value is used and basic consumption is determined in billing.
4. Define and describe "kVA demand" using arithmetic and phasor additions.
5. Observe polyphase kW and kVA demand meters used to measure the demand on 3 and 4 wire loads.

E. Instrument Rated Polyphase Meters ..... 6 Hours

Outcome: Describe various polyphase meters and instrument transformer connections using formula and phasor diagrams.

1. State and verify using phasor diagrams the correct formula of voltage and current used by each meter to register the correct consumption of energy used.
2. Describe the effect of loss of potential on the meter.
3. Describe how to perform a load check to verify the accuracy of a connected meter.
4. Describe the function, operation and hazards of test switches.
5. Describe the standard colour code outlined by Measurement Canada for the wiring between the test switch and meter.
6. List possible reasons for changing revenue meters and describe the steps that should be taken to verify the metering point after the meter has been changed.
7. Connect and verify three phase, three wire, 2 element meter with CT and VT's.
8. Connect and verify three phase wye or delta, four wire with CT and VT's.
9. Verify polyphase instrument rated meter installation for colour codes, connections and grounding.

F. Metering Transducers ..... 3 Hours

Outcome: Describe various transducers used for power measurement.

1. Describe and calculate the input and output ratings of transducers from nameplate data.
2. Describe how the output of a transducer can be changed from current to voltage outputs.
3. Describe the "Hall effect" transducer and its general use today.
4. Connect output of transducer to dc ammeter and determine input amount.

G. Pulse Metering Recording..... 4 Hours

Outcome: Describe pulse metering for power measurement.

1. Describe how auxiliary pulses are produced and describe why they may be required at a metering location.
2. Verify results of metering to be correct from pulses and Ki values.
3. Calculate the watt-hours per pulse (Ki) of pulse initiators using the kh of meter nameplate and pulses per disk revolution.

H. Safety In Changing Meters ..... 6 Hours

Outcome: Describe safety procedures with meter installations.

1. List hazards and describe proper procedures when installing or removing a self-contained meter at a new or existing location.
2. List hazards and describe proper procedures when installing or removing instrument rated meters.
3. Properly verify all self-contained meter connections at the socket and at the terminals of a bottom connected meter by voltage and visual checks.
4. Demonstrate how a connected meter can be verified by checking voltage, current, power factor of load and timing meter disk.
5. Demonstrate safety procedures in changing a meter.

I. Telemetering and Automated Metering Infrastructure (AMI) ..... 3 Hours

Outcome: Describe telemetering and automated infrastructure methods for data acquisition.

1. Describe how it's possible to verify a metering point when using computerized metering equipment.
2. Describe the physical connections required between computer, cell phone and meter or recorder.
3. Describe smart metering and its applications.
4. Describe what information is possible to obtain with these methods of metering.

J. Regulatory Agencies ..... 2 Hours

Outcome: Describe the regulations pertaining to the PSE trade and the government and non-government regulatory agencies for power measurement.

1. State the basic standards for polarity marks and wire color code for secondary conductor connections on instrument transformers for revenue metering.
2. Describe what accuracy range is acceptable and how regulatory agencies test and verify revenue meter installations.
3. Describe what is meant by "seal extension" and what is required by Measurement Canada.
4. Describe what is meant by dispute testing and describe how a dispute test with a customer is performed.
5. Describe what regulations affect revenue metering and how Measurement Canada controls and approves metering equipment.
6. Describe the roles of the regulatory bodies in Alberta associated with transmission and power distribution.

K. Detection and Prevention of Energy Theft ..... 2 Hours

Outcome: Describe methods of detection and prevention of energy theft and diversion.

1. Describe what seals are installed at a metering point by the Utility and Measurement Canada and the importance of sealing programs in the prevention of energy theft.
2. Describe how internal tampering can be done to electro-mechanical meters and describe what safeguards exist to prevent this.
3. Describe how energy diversion can be performed internal or external to the meter.

4. Describe what action an employee should take in reporting a case of energy theft.
5. Describe the safety hazards associated to energy theft and diversions.

SECTION TWO: ..... ADVANCED SUBSTATION THEORY ..... 64 HOURS

A. Power Systems ..... 2 Hours

Outcome: Describe the Alberta transmission and distribution systems and how it relates to other jurisdictions and different bus configurations.

1. Identify and describe common types and functions of power systems in generation including co-gen.
2. Identify and describe the Alberta Interconnected Electrical System. (AIES)
3. Identify and describe common types of distribution systems including overhead, underground and network.

B. Bus Configurations ..... 4 Hours

Outcome: Describe the Alberta transmission and distribution systems and how it relates to other jurisdictions and different bus configurations.

1. Describe the single, transfer, double and ring bus switching systems.
2. Describe breaker and one-half and breaker and one third.

C. System Fault Current ..... 24 Hours

Outcome: Describe system fault current.

1. Identify and describe fault currents including sources, symmetrical/asymmetrical, dc component, X/R ratio and mechanical and thermal stress.
2. Calculate and describe single phasing, open delta and loss of power on the secondaries of various 3 phase transformer connections when primary fuse failure occurs.
3. Calculate wye connected VT secondary voltages on grounded and ungrounded systems.
4. Define the sub transient, transient and synchronous reactance.
5. Describe and calculate the per unit method used in short circuit calculations to determine fault current of line-line-line, line-line and line to ground faults.
6. Calculate circuit impedance using delta-wye and wye-delta transformations.
7. Identify and describe applications for choosing breaker ratings (thermal capacity I^2t), bus rating, relay setting and fuse size from calculated fault levels.
8. Simulate fuse failures on the primary side of three phase transformer banks (wye, grounded wye, and delta) and then analyze the secondary voltages.
9. Simulate the per-unit fault current of a line-line-line, line-line and line to ground faults.
10. Determine the secondary potential transformer voltages that will exist in a grounded and ungrounded system using potential transformers.
11. Observe a simulated supply network, and compare calculated values of short circuit fault MVA to measured values.
12. Observe faults on a radial system.

D. Symmetrical Components ..... 10 Hours

Outcome: Describe symmetrical components of three phase circuits.

1. Define and calculate the positive, negative and zero sequence components for balanced and unbalanced conditions.
2. Calculate relay settings for current unbalance using I_1 and I_2.
3. Determine the positive, negative and zero sequence voltages in a "floating" neutral circuit using the system neutral as a reference.
4. Determine positive and negative sequence currents in an unbalanced three phase load.
5. Draw phasors of the sequence components to show that their sum is equal to the measured currents.
6. Calculate the % unbalance of currents using I_1 and I_2.

E. Precommissioning and Commissioning of Substation Maintenance and Troubleshooting ..... 10 Hours

Outcome: Describe substation commissioning, maintenance procedures and troubleshooting electrical systems.

1. Describe the importance of receiving, cataloguing and acceptance testing new equipment.
2. Identify the prints, standards and specifications required and describe the importance of as-built drawings.
3. Describe the requirement of installation, function, energization and in service checks.
4. Discuss benefits of scheduled inspection and test programs.
5. Describe general maintenance requirements.
6. Verify electrical prints to field wiring, devices and connections.
7. Utilize schematics and wiring diagrams in troubleshooting circuits.
8. Demonstrate basic troubleshooting techniques.

F. Transmission Line ..... 3 Hours

Outcome: Describe voltage regulation on and efficiency of transmission lines.

1. Describe the voltage regulation of a transmission line from no load to full including the effects of power factor.
2. Describe charging current.
3. Describe the factors affecting the transmission line efficiency in ac and dc lines.

G. Substation Communication and Supervisory Control And Data Acquisition (SCADA) ..... 11 Hours

Outcome: Describe Substation Communication and Supervisory Control and Data Acquisition (SCADA).

1. Describe communication media, their functions and applications.
2. Describe the communication protocols and their applications.
3. Describe the purpose and function of Supervisory Control and Data Acquisition (SCADA) and communication cables.
4. Describe procedures for testing and troubleshooting communication cabling installations.

SECTION THREE ..... PROTECTIVE RELAYING ..... 88 HOURS

A. Protective Relaying Systems ..... 11 Hours

Outcome: Describe electrical protection circuits and relaying schemes.

1. Describe the principles of protective relaying.
2. Identify zones of protection.
3. Describe the objectives of primary and backup protection.
4. Describe the protective relay types, functions and device numbers.
5. Identify current and potential transformers and their connections to metering and protection devices on a single line drawing.
6. Describe protective relaying.

B. Overcurrent Protection ..... 25 Hours

Outcome: Describe overcurrent protection.

1. Identify and describe phase and ground protection.
2. Describe overcurrent characteristic curves.
3. Describe overcurrent protection connection in a circuit.
4. Describe clearing times for overcurrent protection.
5. Coordinate relays on a radial system using CT's, relay curves and time dial settings.
6. Using a microprocessor based relay and computer apply and describe the functions including overcurrent protection, automatic reclosure, sequence coordination and breaker interrupting duty.
7. Test electro-mechanical and microprocessor relays.
8. Demonstrate coordination between two overcurrent relays.

C. Directional Protection ..... 15 Hours

Outcome: Describe directional protection.

1. Describe the theory of operation of directional relays.
2. Describe the application and selection of actuating quantities for power directional relays.
3. Describe the application and selection of actuating quantities for current directional relays.
4. Describe the differences in the applications and connections for phase directional, ground directional and power directional relays.
5. Test an overcurrent and power directional relays.

D. Differential Protection ..... 10 Hours

Outcome: Describe differential protection.

1. Identify and describe the theory of differential protection and their applications.
2. Correct CT connections on wye-delta transformer primary and secondary.
3. Identify and describe generator, transformer, bus and line differential protection.
4. Interpret manufacturers' curves for various % slope differential relays.
5. Identify and describe common channel types including pilot wire, fibre optic and microwave.
6. Perform a pick-up, through fault and slope test on differential relays.

E. Impedance Protection ..... 5 Hours

Outcome: Describe impedance protection.

1. Describe the theory of operation of an impedance relay.
2. Describe impedance relay characteristics on the R-X diagram.
3. Describe under-reach and over-reach transfer tripping schemes.
4. Describe quadrature zones of protection.

F. Additional Protective Relays ..... 6 Hours

Outcome: Connect, test and verify additional relays.

1. Describe the application and theory of operation of a frequency and synchronism check.
2. Describe the purpose of reclosing relays.
3. Describe the theory of operation of a network protection scheme
4. Describe the theory of operation of a breaker failure relay scheme.
5. Demonstrate the principles and purposes of auto reclosing.

G. Microprocessors and Logic Relay Functions ..... 16 Hours

Outcome: Describe microprocessor and logic relay functions.

1. Compare digital to analog devices and signals.
2. Describe the common underlying principles of binary number systems.
3. Describe the purpose of logic gates.
4. Show the truth tables and Boolean equation for the common logic gates.
5. Describe the purpose and function of the micro processing unit.
6. Describe the communication protocols and interfaces of protective intelligent electronic devices (IED).
7. Analyze relay human-machine interface (HMI), current, demand values, fault reports and disturbance data.

SECTION FOUR: ...ELECTRICAL CODE AND SAFETY AND WORKPLACE COACHING SKILLS... 24 HOURS

A. Workplace Coaching Skills / Mentoring ..... 4 Hours

Outcome: Display coaching skills.

1. Describe coaching skills used for training apprentices.
2. Review the terms of apprenticeship and describe the advancement criteria for an apprentice within the Power System Electrician trade.
3. Describe the purpose of the apprentice record book role for apprentice and employer in competency task check-off requirements and updating procedures.

B. Alberta's Industry Network ..... 2 Hours

Outcome: Describe the role of Alberta Apprenticeship and Industry Training Board and the network of industry committees that represent the trades and occupations in Alberta.

1. Describe Alberta's apprenticeship and industry training system.
2. Describe the roles and responsibilities of the Alberta Apprenticeship and Industry Training Board, government and post-secondary institutions.
3. Describe the roles and responsibilities of the PACs, LACs and occupational committees.

C. Alberta Electrical Utility Code (AEUC) ..... 6 Hours

Outcome: Understand why and how the AEUC is used to provide minimum standards for utility electrical installations in the province and know who is responsible for utility electrical installations.

1. Describe the sections of the AEUC and their purpose.
2. Locate and interpret the rules in Section 8.
3. Describe procedures to obtain authorization to perform operations or work.
4. Give a typical work situation and be able to identify applicable AEUC rules.

D. Canadian Electrical Code (CEC) Part 1 ..... 4 Hours

Outcome: Understand why and how the CEC is used to provide minimum standards for electrical installations in the province.

1. Locate and apply the general requirements pertaining to protective and control devices.
2. Determine when protective and control devices are required and select the proper types and ratings.
3. Locate and apply the rules pertaining to liquid filled equipment, transformers, lightning arrestors and battery rooms.
4. Locate and apply the rules pertaining to the protection and control of generators.

E. Switching Programs / Single Line Diagrams ..... 8 Hours

Outcome: Demonstrate the ability read single line diagrams, write switching orders and issue Guarantee of Isolation (GOI) orders.

1. Review single diagrams and identify isolation points on drawing and on site to isolate equipment.
2. Prepare switching orders to isolate and issue work clearances or re-energize portions of a substation system using a single line diagrams.
3. Describe the requirements of a GOI, working clearance and lock-out / tag-out procedures.

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